large angle, the rays are refracted into the receiving hat, and produce an effect much larger than when the prism is removed.

An ordinary 9-inch glass lens is next placed near the source, and by means of the light of a taper it is focussed between source and receiver. The lens is seen to increase the effect.

Arago Disk, Grating and Zone-plate.

The lens helps us to set correctly an 18-inch circular copper disk in position for showing the bright diffraction spot. Removing the disk, the effect is much the same as when it was present. Add the lens, and the effect is greater. With a diffraction grating of copper strips two inches broad and two inches apart, I have not yet succeeded in getting good results. It is difficult to get sharp nodes and interference effects with these sensitive detectors in a room. I expect to do better when I can try out-of-doors, away from so many reflecting surfaces; indoors it is like trying delicate optical experiments in a small whitewashed chamber well supplied with looking-glasses; nor have I ever succeeded in getting clear concentration with this zone-plate having Newton rings fixed to it in tinfoil. But really there is nothing of much interest now in diffraction effects except the demonstration of the waves and the measure of their length. There was immense interest in Hertz's time, because then the wave character of the radiation had to be proved; but every possible kind of wave must give interference and diffraction effects, and their theory is, so to say, worked out. More interest attaches to polarisation, double refraction, and dispersion experiments.

Polarising and Analysing Grids.

Polarisation experiments are easy enough. Radiation from a sphere is already strongly polarised, and the tube acts as a partial analyser, responding much more vigorously when its length is parallel to the line of sparks than when they are crossed; but a convenient extra polariser is a grid of wires something like what was used by Hertz, only on a much smaller scale; say an 18-inch octagonal frame of copper strip with a harp of parallel copper wires. The spark-line of the radiator being set at 45°, a vertical grid placed over receiver reduces the deflection to about one-half, and a crossed grid over the source reduces it to nearly nothing.

Rotating either grid a little rapidly increases the effect, which becomes a maximum when they are parallel. The interposition of a third grid, with its wires at 45° between two crossed grids, restores some of the obliterated effect.

Radiation reflected from a grid is strongly polarised, in a plane normal of course to that of the radiation which gets through it. They are thus analogous in their effect to Nicols, or to a pile of plates.

The electric vibrations which get through these grids are at right angles to the wires. Vibrations parallel to the wires are reflected or absorbed.

Reflecting Prism.

To demonstrate that the so-called plane of polarisation of the transmitted radiation is at right angle to the electric vibration,[1] *i.e.* that the wires of the grid are parallel to it, I use the same paraffin prism as before, but this time I use its largest face as a reflector, and set it at something near the polarising angle. When the line of wires is parallel to the plane of incidence, in which case the electric vibrations are perpendicular to the plane of incidence, plenty of radiation is reflected by the paraffin face. Turning the grid so that the electric vibrations are in the plane of incidence, we find that the paraffin surface set at the proper angle is able to reflect hardly anything. In other words, the vibrations contemplated by Fresnel are the electric vibrations; those dealt with by McCullagh are the magnetic ones.

Thus are some of the surmises of genius verified and made obvious to the wayfaring man.

THE REPORT OF THE ASTRONOMER ROYAL.

AT the annual visitation of the Royal Observatory, Greenwich, on Saturday last, the Astronomer Royal presented his report of the progress made from May 11, 1893, to May 10 of this year. We take from it the following information:—

It appears that the average number of transits observed was no less than 31 each day, or if Sundays are excluded, 36. As an instance of the number of observations which were made under very favourable conditions, it may be mentioned that on three consecutive days in February no fewer than 458 transits and 460 zenith distances were observed.

A new universal transit-circle or altazimuth is being constructed by Messrs. Troughton and Simms, and satisfactory progress has been made towards completion. All the heavy portions of the instrument, including the rotating and reversing gear, are made, and have been put together, the object glasses for the instrument and collimators are practically finished, as well as the eye end with its micrometers, and the circles, microscopes, &c., are in hand.

As previously noted in our astronomical column, a valuable gift has been made to the Observatory by Sir Henry Thompson, who has generously offered a sum of £5000 to provide a large photographic telescope with accessories, which would serve as the complement of the 28-inch visual telescope just completed. This munificent offer was readily accepted by the Admiralty, and after careful consideration and discussion, a photographic telescope of 26 inches aperture and 22 feet 6 inches focal length, equatorially mounted, was ordered of Sir H. Grubb on May 5, the instrument to be completed in eighteen months. This telescope will be of exactly double the dimensions (aperture and focal length) of the astrographic equatorial which has proved so successful, and it will be mounted on a very firm stand which will allow of complete circumpolar motion without the necessity for reversal on the meridian, which has been felt as a drawback in the astrographic equatorial. It will be erected on the central tower of the new Physical Observatory, under the 30 feet dome which is shortly to be placed there, and will carry the 12¾-inch Merz refractor as a guiding telescope and the Thompson 9-inch photoheliograph. It will thus be mounted under very favourable conditions for work, and will be in every respect a most effective instrument.

The new 28-inch refracto has been brought into working order after much time spent in the erection of the instrument, in the adjustment of the object glass, and in the provision of various fittings at the eye end. The adjustments were finished by October 1, when, under good atmospheric conditions, the definition was found to be very fine. Since then the object glass has been tested on various objects with very satisfactory results. A sketch of Jupiter and some measures of double stars have been made, and the colour correction of the object glass has been determined on stars by readings for focus at different parts of the spectrum.

The object glass has also been tried in the photographic position, with the crown lens reversed and the lenses separated on the plan proposed by Sir G. G. Stokes. The determination of the best distance between the lenses and the exact adjustment of the crown lens for tilt and centering relatively to the flint has necessarily taken a long time, as small modifications were required in the cells and special contrivances had to be devised for the delicate adjustment of the heavy crown cell and lens. A large number of photographs have been taken at different distances inside and outside of the focus corresponding to different positions of the crown lens, and affording interesting information which will be useful in connection with the Thompson 26-inch photographic telescope.

With the astrographic equatorial, 923 plates, with a total of 2143 exposures, were taken on 183 nights in the year ending May 10. Of these 181 were rejected, owing to photographic defects, mechanical injury, mistakes in setting, the plate being wrongly placed in the carrier, failure in clock driving, and interference by cloud. The following statement shows the progress made with the photographic mapping of the heavens in the year covered by the report:—

	No. of Photos taken.	Successful Plates
Astrographic chart (exposure 40m.) ...	280	220
Plates for catalogue (exposures 6m., 3m. and 20s.)	508	387
Number of fields photographed for the chart		200
Number of fields photographed for the catalogue		367
Total number of fields photographed since the commencement of the work for the chart		333
Total number of fields photographed since the commencement of the work for the catalogue		610

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[1] *c.f.* Trouton, in NATURE, vol. 39, p. 393; and many other optical experiments by Mr. Trouton, vol. 40, p. 398.

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To test the optical photographic distortion up to considerable distances from the centre, seven plates with the Pleiades photographed in the four corners have been measured. It appears that the distortion is practically insensible up to 60′ from the centre, and is still small up to 80′, but is not quite the same in the four corners of the plate. On examination, the character of the images in the four corners was also found to vary slightly, the coma being slightly inwards in one corner and outwards in another. The perpendicularity of the plate and object glass to the optic axis were examined and found to be satisfactory.

SOLAR OBSERVATIONS.

Observations of the sun have shown that the solar activity was fully maintained throughout the whole of 1893, the mean daily spotted area for the year being considerably in excess of that for 1892. The great spot of 1892 February still remains the largest hitherto seen in the present cycle, but in 1893 August a very fine group attained dimensions but little inferior, and the groups of 1893 November and 1894 February were very large. The characteristic of the year was, however, rather the great number of groups visible at the same time than the extent of any one of them. Thus in August and December 1893 as many as 16 or 18 distinct groups of spots were seen on the disk at the sametime.

MAGNETIC OBSERVATIONS.

The variations of magnetic declination, horizontal force and vertical force, and of earth currents were registered photographically, and accompanying eye observations of absolute declination, horizontal force and dip were made as in former years. The period was one of much less magnetic activity than last year, but there was a large increase occurring in 1894 February, at the time of the great sun-spot. Copies of the magnetic and earth current registers during the disturbances of February 20–March 1 and March 30–April 1, have been supplied to Mr. Preece for discussion in connection with disturbances on the telegraph lines.

METEOROLOGICAL OBSERVATIONS.

Meteorological observations have been made as usual. The reductions show that the mean temperature of the year 1893 was 51°·1, being 1°·6 above the average for the 50 years 1841–1890.

During the twelve months ending 1894 April 30, the highest air temperature in the shade exceeded 80° on 28 days. It was 91°·0 on June 19, 93°·0 on August 16, 94°·2 on August 17, and 95°·1 on August 18. In the 53 years since 1841 higher temperatures have been recorded only twice previously (on both occasions in July). The lowest was 12°·8 on January 5, the maximum on that day being only 19°·0 and the mean daily temperature 15°·9. The mean temperature on August 18 was 79°·6, being the highest mean value recorded in August since 1841. The mean temperature of January 5 was lower than any previously recorded since 1841, with two exceptions. The mean monthly temperature was above the average in all months excepting September, November, and January 1894. In May it was 4°·6, in August 3°·9, in March 2°·7, and in April 3°·8, above the average. In November it was 1°·5 below the average.

The number of hours of bright sunshine recorded during 1893 by the Campbell-Stokes sunshine instrument was 1454, the greatest number on record since the commencement of the registration in 1877. This is 171 hours above the average of the preceding 16 years, after allowance is made for the small difference of indication of the Campbell and Campbell-Stokes instruments. The aggregate number of hours during which the sun was above the horizon was 4454, so that the mean proportion of sunshine for the year was 0·326, constant sunshine being represented by 1.

The rainfall for 1893 was 20·1 inches, being 4·4 inches below the average of the 50 years 1841–1890. From March 1 to September 30 (the period of the great drought) the rainfall amounted to only 7·77 inches, while the average for the 50 years 1841–90 for those months is 14·22 inches.

The mean amount of cloud for the year on the scale 0–10 was 5·75. The average amount as determined by Mr. Ellis (*Quarterly Journal Royal Meteorological Society*, vol. xiv.) from 70 years' observations is 6·75.

The outlook as regards instruments and accommodation for them is stated to be fairly satisfactory; but the fact that four vacancies in a staff of twelve persons have occurred during the fiscal year has necessarily caused serious disorganisation of the work, and greatly handicaps progress.

SCIENCE IN THE MAGAZINES.

THERE are few articles of scientific import in the magazines received by us. By this we do not mean to say that science is unrepresented in magazine literature for June, but that the articles, while affording an excellent pabulum for the omnivorous reader, lack originality of thought. They are, in fact, more descriptive than suggestive. "In the year 1887" (writes Mr. Edison, as an introductory note to an article by Antonia and W. K. L. Dickson in the *Century*) "the idea occurred to me that it was possible to devise an instrument which should do for the eye what the phonograph does for the ear, and that by a combination of the two all motion and sound could be recorded and reproduced simultaneously." The development of this idea, and its practical realisation, are well described by the authors of the article on Edison's kineto-phonograph—this being the comprehensive term given to the invention that is able to record and give back the impressions to the eye as well as to the ear. Muybridge, Marey, Boys, and others have shown what can be done in the way of instantaneous photography, but the plan used by Edison to obtain pictures of movable objects appears to differ from any previously used. After many trials, a highly sensitised strip of celluloid one and a-half inches wide has been adopted for the production of negatives, each strip being perforated on the outer edge. "These perforations occur at close and regular intervals, in order to enable the teeth of a locking-device to hold the film steady in the nine-tenths of the one forty-sixth part of a second, when a shutter opens rapidly and admits a beam of light, causing an image of phase in the movement of the subject. The film is then jerked forward in the remaining one-tenth of the forty-sixth part of a second, and held at rest while the shutter has again made its round, admitting another circle of light, and so on until forty-six impressions are taken a second, or 2760 a minute. This speed yields 165,600 pictures in an hour, an amount amply sufficient for an evening's entertainment, when unreeled before the eye. . . . The advantage of this system over a continuous band, and of a slotted shutter forging widely ahead of the film, would be this, that in one case only the fractional degree of light comprised in the 1720th part of a second is allowed to penetrate to the film, at a complete sacrifice of all detail, whereas in the present system of stopping and starting, each picture gets one-hundredth part of a second's exposure with a lens but slightly stopped down—time amply sufficient, as any photograper knows, for the attainment of excellent detail even in an ordinarily good light." The perforations in the film, referred to in the foregoing, are of assistance in establishing harmonious relations between the kinetoscope and phonograph, in making the action recorded by the one suit the word imprinted upon the other. Several reproductions of series of pictures obtained by the kinetograph accompany the article. In order that the subjects leaving their "passing moods" upon the kinetograph film may be brilliantly illuminated, a new kind of studio has been constructed. The building is pivoted at the centre, and is capable of being rotated so as to present any desired aspect to the sun. Another article in the *Century*, entitled "Field Notes," by Mr. John Burroughs, contains some interesting notes on the habits of a few common animals. This kind of contribution is very common in the magazines. "The Dog," by Mr. N. S. Shaler, and "American Game Fishes," by Mr. L. M. Yale, both in *Scribner*, belong to this anecdotal class.

Cassell's Family Magazine contains an article by Mr. J. Munro on "How I discovered the North Pole." The story is, of course, purely imaginary, but the idea upon which it is based might be developed for preliminary geographical exploration. A number of balloons are supposed to have been set free in high north latitudes, each provided with magazine cameras stocked with plates and having long-distance lenses of various focal lengths. Exposures were automatically made at regular intervals by means of clockwork, so that when the balloons were captured, they contained photographs of the tracks above which they had passed. Each balloon also carried a gyroscope mounted in such a manner that when its axis of rotation became vertical—that is, when the balloon containing it was exactly over the North Pole, cameras were brought into action and photographs taken of the earth below.

"The Spring of the Year," in *Longman's*, is an inspiring article written by Richard Jefferies, and found by Mrs. Jefferies among the MSS. left by him. Mr. A. Morgan retails some second-hand information on "Celestial Photography" in the same

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